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THE DOUBLE-DECK BUS
A TRANSPORT AND INDUSTRIAL OPPORTUNITY FOR CANADA

by

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The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre.

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A Design Portfolio (preliminary design for a Canadian double-deck bus) by Guillon, Smith, Marquart and Associates is reproduced in its entirety.	T.N. Smith

17. Abstract

This report describes an opportunity to improve the productivity and fuel economy of intercity passenger and bus parcel express operations in Canada through the introduction of double-deck buses. The operations of Pacific Coach Lines are particularly suited to the double-deck bus, since a deck space limitation on their bus-ferry services can be removed and costs reduced. The limitations of European double-deckers for service in North America, the size of the potential market available and an analysis of the benefits to British Columbia and the country in general, lead to the conclusion that a viable industrial opportunity (manufacturing and export operation) exists. A product design, production and market development strategy is presented.

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17. Résumé

Ce rapport traite de la possibilité d'améliorer la productivité du service voyageurs et du service colis par autobus au Canada, tout en réalisant des économies d'énergie, par la mise en service d'un autocar à impériale. L'idée d'utiliser des autocars à impériale est particulièrement intéressante dans le cas du service bus-traversier desservit par la compagnie Pacific Coach Lines vu la capacité doublée de leurs autocars. Le problème d'espace à bord du traversier est ainsi résolu et le coût du transport est réduit. L'inconvénient d'importer un autobus à impériale européen et de l'adapter au contexte nord-américain; le potentiel du marché à desservir et l'analyse de l'intérêt qu'un tel service apporterait à la Colombie-Britannique et au pays en général sont autant d'arguments qui favorisent l'idée de la fabrication au Canada d'un autobus à impériale, avec les perspectives d'exportation qu'on peut envisager.

Le rapport propose une stratégie visant la conception, la fabrication et la commercialisation d'un tel véhicule au Canada.

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Warm thanks are also given to Mr. Morley Smith of Guillon, Smith, Marquart and Associates and Mr. Lloyd Walker of Hovey and Associates (1979) Ltd. for fruitful discussions of their design concepts.

SUMMARY

The objective of this study was to continue preliminary design and assessment of a Canadian double-deck bus. The study summarizes previous work, presents recent design drawings and assesses the transport and industrial benefits which may accrue to British Columbia and which may be gained through the manufacture and use of double-deckers in Canada.

Pacific Coach Lines Ltd. operates a fleet of 124 single-deck buses in the British Columbia lower mainland, on Vancouver Island and on the bus-ferry service between the city of Vancouver and the Island. Expansion of the bus-ferry service is limited by the amount of deck space allocated by the B.C. Ferry Corp. and serious bottlenecks occur in the peak tourist season. This problem and improved service elsewhere in the system, particularly on the Fraser Valley commuter run, could be resolved by the introduction of double-deck buses to achieve a mixed fleet.

Analysis of the double-decker option shows that 20 double-deck buses could replace 37 conventional buses on the Vancouver to Victoria route and phased replacement of 75 of the older single-deck buses with 40 of the new configuration would provide substantial improvements in system productivity and in fuel consumption. Estimates are that 40 double-deckers in a mixed fleet could provide annual operating cost savings (including depreciation) in the range of $700,000 and fuel savings in the order of 400,000 litres (88,000 gallons) per year.

Preliminary evidence is presented to show that a high capacity, double-deck bus could penetrate the Canadian intercity passenger and bus parcel express market, but that Canadian and U.S. operational requirements may not be met economically by double-deck buses imported from Europe.

Preliminary design concepts are presented for an innovative double-deck bus which could be manufactured in Canada.

The Canadian market for the new design is assessed at 50-60 buses per year, but export markets for buses and engineless kits are also available. Should the double-deck bus manufacturing enterprise be launched in Canada, after prototype development and testing, it is estimated that domestic and export sales could reach an annual level of $40 million by 1986 and $60 million by 1989, by which time Canadian employment in the enterprise would reach 630.

It is recommended that assistance should be provided to Pacific Coach Lines in the acquisition and testing in

revenue service of currently available, imported, medium-technology, double-deck buses. It is recommended that assistance should be provided to develop a Canadian, advanced technology, double-deck bus. Design of the Canadian bus should be undertaken and market surveys and strategies developed under the direction of private industry.

The roles which could be played by industry and governments, federal and provincial, in advancing this transport and industrial opportunity are discussed.

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1. INTRODUCTION

1.1 Background

This report deals with an opportunity conceived by representatives of Pacific Coach Lines Ltd. (PCL) of British Columbia, and the Transportation Development Centre of Transport Canada to improve the level of service provided by PCL in the Victoria-Vancouver area, and also reduce the cost of service. The opportunity may be of interest to a broader community, since the concept employed - the use of special double-deck buses - may be useful elsewhere in Canada, and also offers the prospect for manufacture of an innovative energy-conserving vehicle in Canada and for which an export market might be developed.

PCL, like many other transportation systems in the public sector, operates at a "loss", despite healthy growth in ridership and parcel service. The gap between revenue and expenses is substantial ($7 million per year on operating revenues of around $12 million) and is met by a subsidy from the provincial government, which authority also determines the price the public is to be charged for the service and hence the deficit to be accepted. Since all costs are rising rapidly, major increases in revenue and improved productivity are required to contain or reduce the gap between costs and expense. One possible way to improve productivity and cut costs is by upgrading the aging vehicle stock, where appropriate, with high revenue, high capacity motor coaches which should, at the same time, incorporate innovations to reduce labour costs and fuel consumption per passenger mile of service provided.

There is a world-wide movement toward high capacity buses in both the intercity service typified by PCL's operations, and in urban and suburban transit systems. Because the principal routes for PCL involve a ferry segment between the British Columbia mainland and Vancouver Island, the use of high capacity buses is constrained by the deck space allocated to the company on each ferry. High capacity, articulated buses which are being exploited on land routes are therefore not suitable and after consideration of shuttle and double-deck bus options, the latter has been chosen for more detailed investigation within the specific conditions of the PCL service. This report summarizes that investigation, but also indicates the need to determine whether the double-deck high capacity bus, in a configuration tailored to the geography and environment of Canada could be a cost-cutting and fuel-conserving option

for other intercity routes in other regions of Canada. Despite the high level of use of double-deck buses in European cities the prospect for their use in urban and suburban transit services in Canada is judged to be minimal. The Canadian double-deck bus for intercity movements must differ radically in design and performance from those in extensive use in London and other European cities, many of which buses end their useful life lumbering through Canadian cities in local tourist service.

Although fuel in intercity motor coach services currently does not average more than 10-12% of the total operating cost, and is dwarfed by the cost of labour, the price of diesel fuel has risen five-fold in the past 10 years and this particular fuel may be in critically short supply in the future. It is therefore of interest to compare the fuel economy of the double-deck bus with the conventional bus and the stretched, or articulated, bus, as it is certain that during the operating lifetime of any vehicle purchased over the next five years or so, problems of fuel supply, quality and cost will represent the biggest challenge to bus line operations. The diesel problem may be particularly acute in British Columbia, where even now the burgeoning demand for diesel fuel for many highway and off-highway uses cannot be met from refineries in the province.

Introduction of double-deck buses in revenue service by PCL would provide a demonstration and start-up opportunity for the production of buses in the West. The choice of an innovative double-decker for manufacture would provide an opportunity for export from the region. A share of the world market now developing for high capacity buses could be secured with gains to the region and Canada available in the form of job creation, export earnings, import replacement and the establishment of an innovation-based industrial enterprise.

1.2 Objectives

The first objective of the work undertaken was to determine the feasibility of a double-deck bus designed for PCL's intercity passenger and passenger freight service.

The second objective is to determine the benefits which may accrue to British Columbia through the introduction of the double-deck bus by PCL.

A third objective is to determine the benefits which may be gained through the wider use of double-deckers in Canada and the manufacture and export of modern, passenger-oriented models.

1.3 Contents of the Report

The report contains a summary of the preliminary design concepts for the bus developed by Hovey & Associates and Guillon, Smith, Marquart and Associates, recent technical studies on high capacity buses and the double-decker option - in particular, a description of preliminary designs for a double-deck bus tailored for North American conditions. The particular problems facing PCL are also reported together with an analysis of the viability of the vehicle type and the new design is included, together with recommendations for future action.

This report relies heavily on a previous report, Intermodal Efficiency of the Vancouver-Victoria Bus/Ferry Service and a Baseline Design fo a Canadian Double-Deck Bus - TP 3387 (1), and a Design Portfolio prepared as part of this project by Guillon, Smith, Marquart and Associates. The latter is reproduced in its entirety in this report.

2. PACIFIC COACH LINES AND THE DOUBLE-DECK BUS

2.1 Pacific Coach Lines as a Model

The benefits seen to be available from the introduction of high capacity buses include profit improvement for certain lines achieved through economy of scale, energy conservation and expanded bus manufacture in Canada. The impact and benefits may be argued on a national basis, but in reality the adoption of innovative transportation technologies is a complex process and will be achieved only through the judgement made by individual operating companies that their particular operations and costs can be improved at low risk and in a short time frame by replacement of some of the existing proven vehicle types. It is therefore important that generalizations on the potential and benefits of the double-decker, or other high capacity bus configurations be made only after company-specific investigations have been made. The present investigation begins that process with an examination of the opportunity for the double-deck bus in an intercity and intermodal operation at Pacific Coach Lines Ltd. Other intercity and urban transit systems need to be investigated before the total benefits and risks at the national level to the user and producers can be accurately assessed.

2.2 Pacific Coach Lines System

PCL's business comprises a year-round base-load service to the communities of southern British Columbia, overlaid with a highly seasonal tourist service. The following businesses within the business are identified:

- Commuter services principally in the Fraser Valley area, serving metropolitan Vancouver residents.
- Base-line intercity passenger services on the mainland and Vancouver Island.
- Base-line bimodal service to the community of southern British Columbia, with coaches using ferry deck space allocated by the B.C. Ferry Corporation.
- A seasonal bus-ferry tourist service between the mainland and Vancouver Island, of particular importance to the business community of the Island.
- A bus parcel express service of growing importance to the small business community.

. (A long distance tour and charter service operated by PCL was recently discontinued despite profitability).

The routes travelled are mapped in Figure 1.

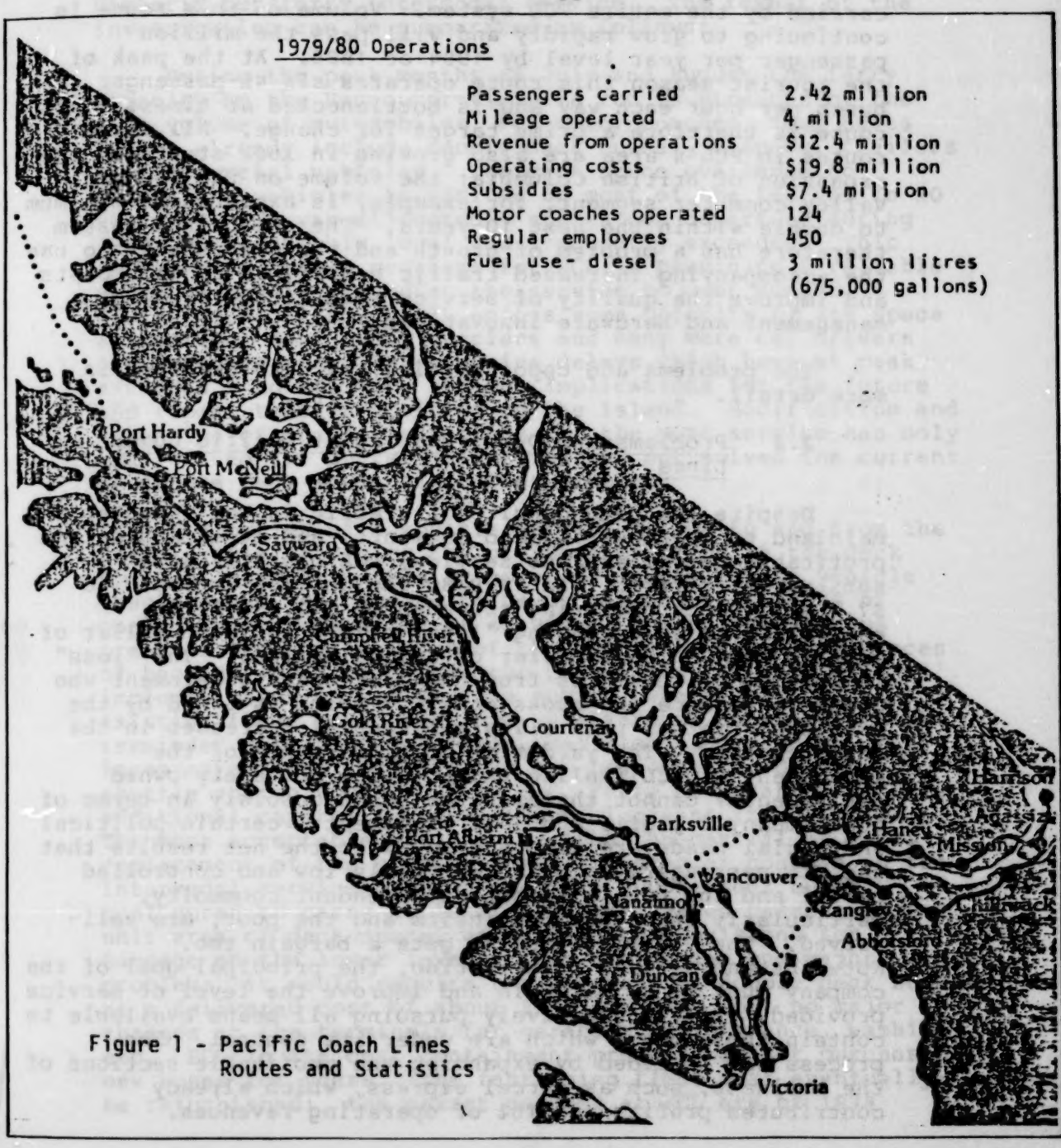


Figure 1 - Pacific Coach Lines Routes and Statistics

The Vancouver-Victoria route has been judged to be the busiest intercity bus connection in Canada in terms of passenger volume: the current level is 800,000 passengers carried per year - one third of the total of passengers carried by the entire PCL system. Volume on this route is continuing to grow rapidly and will pass the million passenger per year level by 1984 or 1985. At the peak of the tourist season this route operates six 45-passenger buses per hour each way and is bottlenecked at times: this route is therefore a prime target for change. All other routes in PCL's area are also growing in lock step with the expansion of British Columbia; the volume on the Fraser Valley commuter segment, for example, is expected at minimum to double within the next 10 years. The entire PCL system therefore has a problem of growth and the opportunity to use the accompanying increased traffic density to contain costs and improve the quality of service even further through management and hardware innovations.

The problems and opportunities are next examined in more detail.

2.3 Problems and Opportunities at Pacific Coach Lines

Despite the high density of traffic in the commuter and mainland to Vancouver Island segments, and an expanding and profitable parcel express service, PCL operates at a substantial deficit. In 1979/80 the deficit amounted to $7.4 million on operating revenues of $12.4 million, equivalent to an operating "loss" of 37¢ for each dollar of cost, or 60¢ on each dollar of earned revenue. The "loss" is made up by subsidies from the provincial government who chose to balance the books at PCL - which is owned by the province - rather than allow substantial increases in the fares charged. The yardstick of performance of the management of PCL (unlike those in the privately-owned equivalents) cannot therefore be counted solely in terms of the company's profit and loss statement: certain political and social needs are also served, with the net results that the PCL passengers enjoy an extremely low and controlled tariff and the public transport-dependent community, particularly the aged, the infirm and the poor, are well-served. The visiting tourist gets a bargain too. Notwithstanding this contribution, the principal goal of the company must be to maintain and improve the level of service provided, while aggressively pursuing all means available to contain those costs which are under its control. The process can be aided by expanding the profitable sections of the business, such as parcel express, which already contributes profits and 15% of operating revenues.

As one avenue to improved service and cost reduction, PCL, in conjunction with the Transportation Development Centre of Transport Canada, evaluated a number of options for improving the cost and debottlenecking the Vancouver-Victoria bus/ferry intermodal service. The result of the investigation can be summarized as follows:

During the peak months of July and August the ferry capacity on the Vancouver-Victoria run is strained by the high volume of automobiles, PCL motor coaches, tour buses (which already include double-deck buses), campers, trailers and commercial vehicles. The deck space available to overheight vehicles is limited on most of the ferries to 20 vehicles. PCL was allocated 5 spaces per departure during 1980, although this level was frequently exceeded. This restriction causes problems for PCL in providing a reliable schedule and in expanding the service to meet demand. Furthermore, although PCL enjoys some priority by its space allocation, many other carriers and many more car drivers are inconvenienced by extensive delays which have at peak exceeded 5 hours, with serious implications for the future and repeat tourist business on the island. Modification and expansion of the ferry vessels for the peak service has only ameliorated the current situation and not solved the current or future deck space limitation problem.

The option of a shuttle service by PCL to and from the ferry, while providing the ultimate solution to the deck space problem at little or no added investment or vehicle obsolescence, was judged to be unacceptable in terms of convenience and quality of service: one of the serious problems was the handling of the more than 2 million pieces of baggage which accompany the passengers. A partial implementation of the shuttle option, wherein half of the existing fleet would continue as a through service with the remainder providing a shuttle, was also judged to be inconvenient and confusing to the passengers. Either shuttle option would require B.C. Ferry Corporation to make additional capital investments and increase its manpower. The most acceptable options involved the partial or total replacement of the conventional 45-passenger coaches in the intermodal service by high capacity double-deck buses configured to carry at least 50% more seated passengers per unit area of deck space, with adequate provisions for baggage on the lower level. This option has one major problem: it would require the purchase of double-deck buses at a delivered cost of about $400,000 each, but no major changes at the terminals for garaging, maintenance, washing, etc. PCL in its cost containment program has not purchased new buses for years. The fast aging fleet must eventually be refurbished: the newest coaches at PCL are of 1974

vintage and 30 of the fleet of 124 active motor coaches are over 18 years old.

2.4 Cost Containment with Double-Deck Buses

Hickling-Partners Inc. examined the logistics and costs of the existing bus/ferry service between Vancouver and Victoria and compared it to four options based upon the introduction of shuttle service, a notional fleet of double-deck buses, or a mixed single/double-decker fleet operation.

The logistics investigation calculated the number of vehicles, one way trips and ferry crossings required to provide the current level of service at peak and off-season. During the peak July-August period, the number of bus trips could be reduced and substantial savings achieved through the use of high capacity buses, whereas the larger units would operate at higher overall costs in periods of minimum ridership when even the present single-deck motor coaches are not filled. The Hickling report suggests that the use of double-deckers with a maximum passenger carrying capacity of 1.5 times that of the current vehicles could reduce the number of vehicles required to 25 from the present 37. We have examined the use of double-deckers of higher capacity (90 seat versions) using the Hickling methodology and find that the annual cost of the service could be reduced by $700,000 per year or so, if a new fleet of 20 double-deck buses were purchased by PCL, even when the added capital-related costs (amortization of purchase costs of $400,000 per bus) are included. The reductions arise from the overall reduction in the number of trips and ferry crossings which may be achieved, with the savings generated principally from driver and related administrative costs, lower fuel, tire and other distance-related items, and reduced tolls to the ferry company. The estimated savings presented in Table 1 are based upon the present level of service.

The projected level of savings at $700,000 per year, or 20% of total costs, will increase sharply in the future because:

- The existing aging fleet will deteriorate to the point where maintenance costs become excessive unless the fleet is modernized. Annual costs in the present system will therefore increase: the choice lies only between increased capital expenditures on new equipment, or increased operating expenditures on maintenance and down-time. (The quality of the ride and service will also deteriorate unless new equipment is provided.)

	Current Costs (1)	90 Seat Double-Decker (2)	Savings Added (expense)
Vehicles operating costs	$485,000	$420,000	$65,000
Hourly cost (principally labour and overhead)	1,906,000	1,250,000	656,000
Vehicle amortization cost (3)	482,000	715,000	(233,000)
Ferry tolls	628,000	415,000	213,000
Total annual cost ($1981)	$3,501,000	$2,800,000	$701,000

Notes: (1) Hickling-Partners' estimates

(2) Logistics and costs revised to 90-seat vehicle

(3) 20 buses with 90 seat capacity plus spares, replace 37 single-deck units

Table 1 Vancouver-Victoria Service

- The growth of demand for the service must be met. New equipment again must be provided and the continuation of the current mode of operation with new single-deck buses will only serve to perpetuate the company's deficits. The new configuration can be phased in to meet the increasing demand for service. An improvement in the quality of the ride could well increase ridership and revenues.

- Ferry fees will increase at minimum linearly with growth of the vehicle fleet, but can be contained with phased introduction of the double-deck bus service. (A further longer term saving comes from the deferment of the need for expansion of the ferry fleet, which will impact somewhat upon PCL in the form of higher tolls from high cost ferry and infrastructure construction costs which must be recouped from users and very substantially from the provincial treasury which must finance ferry expansions).

- The double-decker and other high capacity bus configurations are effective means for the reduction in use of diesel fuel and lubricating oil per passenger carried. The cost of petroleum-based products will continue to outpace any increase in the rate of growth of revenues and use of the double-decker option will be essential to minimize this burden. It will be shown later that restricted supplies of diesel fuel are expected in the future. In due course this will have a severe and adverse effect on the frequency of service and costs, the full impact of which can be minimized with fuel-efficient double-decker vehicles. Over the 20 year life of a bus, impressive oil savings can be accumulated through the higher capacity vehicle option.

- The PCL system has a good fuel economy record for a motor coach operation with a current vehicle average of 41 litres per 100 kilometres (6.75 mpg) despite the high average age of the vehicles in service. In the 12 month period ending March 1981 the system used some 3 million litres of diesel fuel (675,000 gallons). Introduction of 40 double-deck buses with modern fuel-efficient engines could reduce fuel consumption in the PCL system by at least 400,000 litres/year (88,000 gallons). Replacement of the equivalent capacity of 75 of the older existing coaches with new single-deckers could also save fuel, but the annual savings would only be about 150,000 litres (33,000 gallons). The oil saving increment from use of the double-decker option is therefore estimated at 250,000 litres (55,000 gallons) per year. With lubricating oil savings added the annual petroleum product savings would therefore be in the $70,000 range at the existing level of service. By the time 40 units were in service, the level of savings would be expected to exceed $100,000 per annum.

- Particular designs for the double-deck bus suited to PCL service emphasize the storage space which can be provided, not only for passenger baggage, but also for parcels in express parcel service. A walk-in baggage/freight compartment is feasible. The ability to exploit the profitable parcel express segment of the business could further widen the future gap between the total costs of operating a double-decker fleet and a single-decker fleet.

- PCL management has in the planning stage a highly cost-effective route in which double-deckers would serve the high density morning commuter stream into Vancouver, continue on to provide high capacity bimodal service between the mainland and Vancouver Island, and return to serve the commuter market during the evening exodus from Vancouver city. This arrangement could offset the uneconomic aspect of the present union-management collective agreement which precludes split shift operation in the system, requiring two drivers for each round trip commuter service, each driver effectively producing only one paying load per shift.

2.5 Further Assessment of Double-Deckers in the PCL System

The measurable benefits which would accrue to PCL through fleet diversification with double-deck buses reported in the foregoing would be accompanied by a further set of benefits which cannot readily be measured, but which nonetheless will eventually reflect on the survival of the enterprise, the quality and scope of the service, and the speed with which revenues can be increased and the growth in costs curtailed.

Many of the benefits to be described could be gained from the use of either of the high passenger-carrying options - the articulated bus or the double-decker. For PCL, particularly in the short term, the diversification of the vehicle fleet should be confined to the addition of the double-deck bus service, since the articulated bus would not contribute to the solution of the deck-space limitation on the ferry routes and gives a lower seat capacity than the double-decker. The articulated bus has its principal role in urban service where standing room capacity may be used; PCL has a "no standing" policy. The principal reason for confining the first PCL diversification to double-deckers is to contain the problems in driver and maintenance mechanic training, and to minimize the changes in physical plant which must be made at the terminals and garages to process the high capacity units.

The intangible or currently unmeasurable benefits seen to be available to PCL through the addition of double-deck buses lie in the areas of: improved management control of operations and planning; the strengthening of the service and the image of service conveyed to the British Columbia public and legislators who greatly influence the long term policies of the corporation - particularly those related to investment, pricing and routing; and the provision of a new

level of flexibility to operations whereby revenues from profitable services, such as parcel express, can be increased.

The contribution to improved management control would develop from phased introduction of the high capacity buses to produce an optimized mixed fleet, smaller in total number of vehicles than at present, with the least productive of the current set retired.

The need for increased levels of staffing and for expanded garage, maintenance and terminal facilities normally required to match the growth of ridership could be sharply reduced and the possibility also exists that advantage could be taken early in the program of normal staff attrition to reduce the labour force. The higher earning capacity of the double-decker could ease the burden of future wage increases and perhaps provide a tool for renegotiation of certain practices and restrictions, particularly if, as was the case in the New York City demonstration (2), a modest premium was paid to drivers in double-decker service on the highest density vehicles. On the planning side, the introduction of high capacity units would provide a strategic reserve of passenger-carrying capacity for short term deployment in charters; in peak conditions such as commuter service; service for special events; and for long term deployment in expanded capacity on critical routes.

A further aspect is an improved ability to plan a more fuel-conserving fleet and to minimize the requirement for expanded storage facilities against emergency shortages in supply or delivery of fuels. Addition of new vehicles could provide an opportunity to prepare for the utilization of alternative engines and fuels; the larger volume available in the double-deck bus would greatly assist this. Retro-fitting of the existing vehicle mix would be so expensive as to be impracticable.

Many opportunities are available to improve the service and the image of the service through the addition of double-deckers. The removal of capacity constraints through added seating capacity on critical routes and the opportunity to speed up the service is one possibility. Another is to meet the well-known preferences of the public for less noise, vibration, more comfortable seating and easier access to the interior, all available in new designs and larger vehicles. The new vehicle designs developed as part of the present study show that these can be coupled with innovations to provide better views for the passenger, particularly from the upper deck, easier movement within the bus, large walk-

in baggage storage capacity and provision for the infirm and handicapped with dignified wheelchair access through wide doors, low floor height and wide aisles. All this can be achieved within a total vehicle height dimension no greater than that of the conventional tractor-trailer.

As discussed later, this new level of convenience and comfort for the bus passenger would be achieved through innovative design to provide an attractive external appearance with a vehicle length no greater than existing motor coaches. The image created among the non bus-using public, as well as PCL's customers, would be enhanced. Coupled with improved fuel economy and future compatibility with non oil-based fuels available in the new design, the image created among all sectors of the public in British Columbia should be favourable and serve to still much of the criticism when increased fares and investment take place. These are inevitable whether or not the step is taken to boost the company image and improve the quality of the service through modernization of the vehicle stock.

The larger space available in the double-deck bus provides an opportunity for the inclusion of convenience and revenue-generating features not economically feasible in the conventional motor coach. The rapid growth of bus parcel express is expected to continue and would be boosted by designs with large baggage and walk-in cargo space which could accommodate even items of freight than now possible, with important and economic services provided to small business, with again a significant contribution to fuel conservation in the province. The design freedom inherent in the larger space available in the double-decker will permit the introduction of luxury seating and toilet facilities, which may be inducements to expanded tourist travel within the system and the province. In this connection it is worth noting that in Europe double-deck buses, even articulated double-deckers, are increasingly used in the tourist business and that in the first days of the urban transit double-deck bus in Germany a premium was charged for seats on the upper deck.

The decision made by PCL to construct a new terminal in Victoria conforms to the opportunity to introduce the double-deck unit since the new terminal can be designed to accommodate this type configuration and the cost of conversion of the existing Victoria terminal (though modest) can be avoided.

2.6 Interim Conclusions

From the considerations given above, it is concluded that a number of interests in British Columbia would be served by the testing and, if successful, the introduction of a number of double-deck buses into revenue service by Pacific Coach Lines. Many of the benefits foreseen can be achieved by the introduction into service of proven double-deck buses manufactured in Europe. The Neoplan buses from West Germany appear to be the best available and these may be manufactured shortly by a subsidiary now being established in the U.S.A. The market for motor coaches and especially for high capacity versions is expanding rapidly and the importation of European designs of double-deck buses into New York City and Los Angeles shows that extensive modifications are required to provide the level of comfort and freedom from maintenance problems required in the North American market.

This investigation therefore briefly examines the opportunity that could be available for the manufacture of double-deck buses and their use, not only in the Pacific Coach Lines system, but elsewhere in Canada. Before proceeding with a description of the larger market and production opportunity, we will summarize the benefits to British Columbia from the use of double-deck buses on the mainland and Vancouver Island.

2.7 Summary of Benefits to British Columbia from PCL Adoption of Double-Deckers

The benefits to PCL previously described relate to: the containment of costs; modernization of the fleet through investment in double-deck buses; the opportunity to provide an improved level of service, particularly on the Fraser Valley commuter and Vancouver to Victoria runs; the ability to expand revenues on parcel service; and improved planning and operational flexibility.

The benefits to the British Columbia public include: an improved level of service, principally in the elimination of delays on the ferry route; the largely unseen containment of fare hikes for passengers, or a proportionate containment of increases in provincial and municiapl taxes; a reduction in the number of motor coaches operating into and within Vancouver and Victoria with ridership capacity maintained; substantial improvements in the quality of the ride, particularly for the handicapped; benefits derived from contributions made by the improved, leaner PCL service to the business community which will impact upon the economy of

British Columbia and the earnings and taxes of the residents.

The benefits to business include: improved flow of commuters to Vancouver; improved traffic flow aiding continuation of the expansion of tourist traffic and derived trade in Vancouver Island from tourists on the buses and other vehicles carried to the Island by ferry; improved parcel express service offsetting the decline in service provided by the Post Office; adapting to the need of the small business community to deliver small loads and parcels by public vehicle (rather than by partially filled, uneconomic, company-owned vans); and providing a cost-saving tool for small business by means of which small product inventories can be maintained when speedy delivery can be obtained by bus from centralized warehouses to the customer, construction site, store or factory. Business also shares in the benefits of containment of costs and tax increases which flow from a reduction in the subsidy paid to PCL.

Benefits to the government of British Columbia (provincial and certain municipalities) may arise through: containment of the call for increased transport subsidies and a reduction in the pressure for unpopular tax increases and/or fare increases; the opportunity to further rationalize the public transport services, or to divest the province of its ownership in PCL should profitability be established; and a reinforcement of other measures taken by the government of British Columbia to reduce the hazard to transport in the province arising from future oil price increases and fuel supply problems. A particularly interesting synthesis of these problems and opportunities would be developed if the PCL innovation were accompanied by another in the manufacturing sector, with the PCL order serving as a basis for the commercial proving and initiation of bus manufacture in the province.

3. THE BROAD MARKET FOR DOUBLE-DECK BUSES

3.1 The Rationale for High Capacity Buses for Passenger Transport

Although cost and energy efficiencies of rail and bus travel can change relative to each other, depending upon the intensity of the traffic pattern and the basis used for the calculations, it is certain that the high fuel efficiency of buses used in intercity travel coupled with the flexibility of that mode will ensure continued growth. At the moment, bus manufacturers in Canada report that the demand for intercity buses exceeds present production facilities and this is confirmed by the escalation of used bus prices to the point that 3 to 4 year old buses are selling at prices substantially in excess of their original purchase price and many operators have been forced to refurbish old vehicles that would otherwise have been replaced. This demand reflects the value of the service provided by the intercity bus operators, the effect of rapidly escalating gasoline prices on automobile travel, and a healthy export business for buses manufactured in Canada (the required diesel engines are made in the U.S.A., however).

Modern intercity buses, even when operated at an average of 50% or so of available capacity, most often provide the lowest cost and best energy efficient means of transportation. Costs per passenger/kilometer average 4.25 to 4.5 cents for intercity bus travel, compared to an average cost of about 14.5¢ for rail. The high loadings possible with intercity buses in Canada provide 53 passenger km/litre of diesel fuel (144 passenger miles per gallon), while the intercity rail gives 17 passenger km/litre (about 47 passenger miles/gallon).

At 50% of capacity the intercity bus averages 43 passenger km/litre of diesel fuel (116 passenger miles per gallon); in charter and tour service with higher load factors, this rises to over 75 passenger kilometres/litre (200 passenger miles/gallon). Despite these low costs and low fuel consumption levels, intercity bus operators must continually seek to improve productivity and fuel consumption to maintain profitability (or contain losses) and to compete in high volume passenger corridors with subsidized rail or air service. The charter, tour and special service aspects of the intercity bus industry are also growing rapidly and profitably, but the special conditions of this market call for increased space per

passenger, increased baggage and toilet facilities, and for parcel services an increased freight area is required.

The potential market for new bus configurations for the expanding intercity transport market with higher productivity and reduced fuel consumption is unknown. No comprehensive study has been undertaken relating to the type of equipment best suited for particular intercity routes or particular types of service, although a 1979 preliminary feasibility study by N.D. Lea (3) indicates a potential for operating cost savings of 7-20% on certain passenger corridor routes in Canada. This corresponds with European experience. A comprehensive new investigation is required, not only to guide the industry in its selection of bus types for the future, but is urgent in view of announced passenger rail closings and the National Energy Program's goal of oil self-sufficiency for Canada within the decade. A further reason for such a comprehensive study would be the early definition of the opportunities in Canada for expanded bus manufacture and what proportion of the expansion should be in conventional, articulated or double-deck buses. In the absence of such a comprehensive view, we must rely upon qualitative assessments and experienced guesswork for a market analysis.

3.2 Oil Supply Considerations

Although the principal pressure on intercity bus operations is one of cost in which the cost of labour predominates (and which may be partially ameliorated by use of high capacity buses where traffic density allows), the major threat to the continuation of service and expansion of the system lies with the supply of fuel. Fuel cost is important also, but is only one element of cost - albeit an uncontrollable and fast growing element.

The National Energy Program (4) calls for a sharp reduction in the total use of oil by 1990, at which time imports are to be terminated. Heating oil use is to be curtailed by wider use of gas and electricity, but the allocation of oil to the transport sector is unchanged. This implies that the expected growth in transportation, which to date has tracked economic growth, must be achieved without adding to transport fuel demand. The containment of transport fuel use will be accomplished by conservation and perhaps also in part by use of alternative fuels such as alcohol and propane. The conservation route will involve substantial conversions to fuel-efficient diesel engines which will create a pressure of new demand for this commodity. Unfortunately, the amount of diesel fuel available per barrel of oil refined is limited and shortages

of diesel fuel are certain to arise if the projected conversions to diesel occur. Bus operations, the trucking industry and industries such as agriculture, fisheries, forestry and mining will compete for the available supply. There is a shortage of overall refining capacity in British Columbia which will exacerbate the supply position there. The coming squeeze on diesel fuel supplies and quality is therefore one reason for anticipating that high capacity buses with lower fuel consumption per passenger or unit of freight carried will be required in substantial numbers in the future. The delays in implementing oil agreements and Canadian synthetic crude production from tar sands and heavy oil increase the jeopardy to fuel supplies, reinforcing the need in Canada to seek every opportunity to reduce transport fuel use. The introduction of high capacity buses into intercity (and perhaps also selected urban) routes therefore has a strategic dimension in addition to the economic dimension of driver productivity/cost containment at the industry level and the balance of payment issues at the national level.

We do not know exactly how fuel-conserving the high capacity bus options will prove to be in scheduled service since that depends not only upon the fuel consumption of the new engines now being manufactured, seat capacity in the vehicle and the occupancy rate, but also upon innovations in scheduling and routing that are available with the larger buses. The preliminary designs of the Canadian double-decker developed by Hovey and Associates and Guillon, Smith, Marquart and Associates also call upon innovations in materials engineering to reduce weight and upon new aerodynamic designs to reduce air drag at high speed, both of which will have a significant effect in further reducing fuel consumption. In the case of Pacific Coach Lines we have been able to make a preliminary assessment of the fuel conservation potential: in other cases we would expect to obtain improvement in fuel use which parallel improvements in driver productivity.

3.3 A Summary of High Capacity Bus Experience and Designs

Until recently the designs and methods of constructing intercity buses in North America had not changed significantly for 20years, the only outstanding developments in the period being the introduction of the 40 ft 3-axle bus to replace the 35 foot 2-axle model and the introduction of a heavy duty automatic transmission. The 40 ft long models gained immediate acceptance, since they improved driver productivity and reduced costs. In other respects the standardization of designs and even of engine offerings have

reduced vehicle production costs, maintenance and inventory charges through the ensuing economies of scale.

In the same period in Europe, where different market conditions prevail and where a large urban market and a profitable tour and charter market exists, innovations in bus designs have producted articulated buses with lengths up to 21.4 metres (70 ft.), seating 80-100 passengers, and double-deck buses of similar capacity used in urban transit and intercity touring service (rail prevails still for the intercity non-touring segment) and even articulated double-decker luxury class "jumbo" systems.

Articulated buses of European origin are gaining acceptance in U.S. urban transit systems. After successful trials in many U.S. cities and solution of the usual problems involved in supplying spares and converting European-manufactured units to suit the North American environment, the U.S. market has developed to the point where between 400 and 500 articulated buses were ordered in 1980, with more orders in prospect. General agreement, too, was reached with the opinions expressed by researchers at the National Transportation Centre, Pittsburgh, that "high-capacity buses, deployed in imaginative ways, are an imperative need to transit, outranking all other hardware priorities" (5).

Articulated bus manufacture for urban transit applications is beginning to gain momentum in the U.S. with Neoplan buses scheduled for assembly in Colorado and the joint operation of MAN of West Germany and A.M. General supplying an increasing proportion of the U.S. requirement. Buses using Hungarian and Belgian components and technology are also being assembled in the U.S. by Crown Coach Corporation and Eagle respectively. There is much action in Canada too with manufacture underway at General Motors of Canada of a series of 53 articulated buses for city service ordered by the province of Ontario, 21 of which will be delivered to the Ottawa-Carleton transit authority (OC Transpo) in May 1982. Other articulated units are on test already in Alberta, with trials underway in Edmonton and Calgary of European articulated buses in city service. On the intercity transportation front, Voyageur Enterprises of Quebec has a trial in progress upon an articulated Neoplan unit in service between Ottawa and Montreal and the Quebec coach manufacturer Prevost has undertaken the design of an intercity articulated bus with some $2.2 million of financial assistance provided by the federal government department of Industry, Trade and Commerce.

Double-deck buses have not been tested to the same degree in the U.S. or Canada and there is no current commitment to design or manufacture in North America, although Neoplan assembly in the U.S. is a possibility. In the U.S. tests of the double-decker option have been limited to a test of 8 British Leyland 68-seat units in New York City and 22 Neoplan 84-seat units in Los Angeles (2). The Los Angeles test involved an express commuter service and freeway operation which somewhat resembles the Fraser Valley commuter run of Pacific Coach Lines. Experience in Canada is limited to sightseeing applications, only a few of which use new vehicles and all of which use low technology double-deckers.

The U.S. experience with double-deck buses in these limited demonstrations indicated problems with heating and cooling, certain problems with spares supplies and service and associated mechanical problems, all attributable to the attempt to introduce inadequately "Americanized" units of European manufacture into the more severe U.S. environment. Passengers reacted very favourably, however, to the double-deckers, preferring that configuration over the conventional single level bus. Passengers commented on the improvements in ease of boarding (wide doors in double-deckers) and walking through the bus, seat comfort, improved internal environment, lower noise level and improved visibility. Stairs were not found to be a problem, except for the elderly and handicapped. In Canada double-decker experience is limited to their use in sightseeing service, where low technology and often old units are employed.

The European experience with double-deck buses is not directly transferable to Canada, since most double-deckers in use are for urban transit, where space limitations on city streets are more critical than in most Canadian cities. In Europe some 15,000 double-deck buses are used in urban transit systems. Only a few hundred are used in intercity long distance passenger transport; the principal use in this area being tour bus operators, who report operational savings up to 15% for the double-decker versions over the single level types. An intercity motorway run in England (6) between London and Blackpool encountered cross-wind problems and difficulties in restarting from a parked position on soft road shoulders, but this may be due to particuliarities of the Leyland tall design and engine placement used in urban transit designs and not an inherent problem of double-deckers designed aerodynamically, especially for intercity movements.

Tables 2 and 3 present comparisons of the specifications and performance of conventional, articulated

and double-deck buses based upon manufacturers' data - particularly Neoplan for the high capacity types. The most interesting comparison is in vehicle height, where the Neoplan double-decker version with 99 seats (and a length of 12 metres) is shown to be only the height customary in tractor-trailer combinations, which may also reach lengths greater than that of the articulated bus. The height factor is emphasized in the sketches of the potential Canadian bus prepared by GSM and Associates (section 4). Table 2 also shows that the high capacity buses are less demanding of road space and impact less on the highway surface (overall weight and weight per axle) than tractor-trailers in common use throughout Canada. Table 3 demonstrates the efficiency of the double-decker high capacity option for seated passenger transportation, where the absence of the hinge required in articulated buses and the large unimpeded area available on the upper deck more than compensates for the stairs. The lower overall vehicle weight and the weight per passenger in the double-decker version provides a reserve of power for smooth acceleration, hill climbing and added freight. If required in the future, the power reserve could be tapped to reduce fuel consumption through downrating engine speed.

3.4 European Double-Deck Bus Designs for Canada - Some Conclusions

From the limited double-deck bus experience in North America and the specifications and performance cited, it is concluded that:

- The concept of utilizing double-deck buses in selected intercity service in Canada is sound, bearing in mind bridges and other structures may limit the routing to those available to tractor-trailer combinations.

- The opportunity for use of the double-deck configuration in urban service is very limited due to the bus seating/standing ratio in most Canadian cities and the infrastructure modifications required.

- European-built double-deckers may provide sufficient comfort and service in the special environment of British Columbia's lower mainland and Vancouver Island if retrofitted, but extensive modifications will be required to expand the market to include other regions of Canada and the U.S.A.

Model	Dimensions (metres) Height	Width	Length	Seats (2)	Cargo Capacity m^3	Approx. 1981 cost $delivered (1)	Axles number	Loaded weight, Kg
Neoplan N426/3 Double-decker	4.0	2.5	12.0	99	11	400,000	3	22,000
Neoplan Articulated (3)	3.5	2.5	18.0	68	15	420,000	3 (or 4)	24,000 - 28,000
MCI (MC8) Conventional	3.3	2.5	12.0	45	6.1	130-150,000	3	16,300
Prevost Conventional	3.3	2.5	12.0	45	6.8	125-175,000	3	19,100
Compare with typical Tractor-Trailer combination used in Ontario, Quebec, Alberta	4.0	2.5	20	N/A	100	N/A	5	60,000

Table 2 - Comparison of Intercity Bus Options: Specifications

Note: (1) With options for intercity included, such as washroom.
(2) Standing room for Neoplans is: articulated design - 72 passengers, double-decker - 31.
(3) Neoplan literature indicates they also supply articulated single-decker designs of 4 metres in height.

Sources: N.D. Lea Associates "A Feasibility Study of the Introduction of Larger Capacity Intercity Buses", 1979 (updated).
Neoplan product brochures, R.F. Webb Corp. databank

	3 axle Neoplans Double-decker	Articulated	Implication
Seats ratio	3	2	Double-deckers preferred for long distance travel
Total seats + standing	1	1.1	Artics. preferred for high density urban traffic
Empty weight/seat Kg.	136	198	Higher initial cost and fuel costs for artics. indicated
% gross weight available for freight and passengers	39%	42%	Not limiting in passenger transport, but may affect high freight loadings
Power H.P./tonne gross weight	12.7	10	Double-decker has power reserve for hills, winds and speed
Useful traffic floor area m^2	55	39	Double-decker has potential for greater passenger comfort and amenities due to upper deck
Ratio of useful area to traffic area	2	0.9	Hinge in artic. consumes useful area
Seats/m^2 of traffic area	3.3	1.5	
Freight/baggage volume m^3	11	15	Seats downstairs in double-decker can be replaced to give added baggage and freight capacity

Table 3 - Comparison of Intercity Bus Options: Performance

- Attention to spares and the level of field service demonstrated by European suppliers are not up to N. American expectations and requirements.

- The prototypical (small volume, customized) level of manufacture of double-deck buses in Europe will allow for the incorporation of North American engines and transmissions into purchased buses, which is essential for maintenance compatibility.

- Purchases of engines, transmissions, air conditioning and numerous other parts needed to bring the European double-deckers up to the required Canadian level of mechanical specifications will mean substantial subassembly in North America. This offers a joint venture opportunity, should adequate North American sales develop.

- The European double-decker models, while superior in capacity and customer appeal to the current crop of North American conventional buses, are capable of so much further improvement, particularly with respect to passenger headroom, overall comfort and stylish appearance, that consideration should be given to the design and manufacture of a double-deck bus in Canada.

- Meanwhile, experience gained with a few European imports would provide engineering and passenger and freight service information while the public acceptance of the new configuration in intercity service could be assessed.

The following section presents the tentative Canadian design for the intercity bus developed principally by Guillon, Smith, Marquart and Associates and an evaluation of the market for it.

4. A PRELIMINARY DESIGN FOR A CANADIAN DOUBLE-DECK BUS

4.1 The Baseline Design

A baseline design for a Canadian-built bus, which would seat 92 passengers in comfort, has been developed by Hovey and Associates and Guillon, Smith, Marquart and Associates.

4.2 Overall Concepts of the Baseline Design

The basic design criteria were stated as:

- To incorporate available state-of-the-art technology in a double-deck, custom built, service vehicle, which will comply with the dimensional and weight constraints of existing and/or proposed provincial, national and world markets.

- The design to combine the latest safety, comfort, energy saving and environmental engineering techniques, while retaining ease of mechanical and body servicing and providing facilities for the handicapped.

In practice it was recognized that profitable manufacture in Canada would also require a number of specific manufacturing, passenger and operational guidelines to be used in the design.

4.2.1 Manufacturing Guidelines

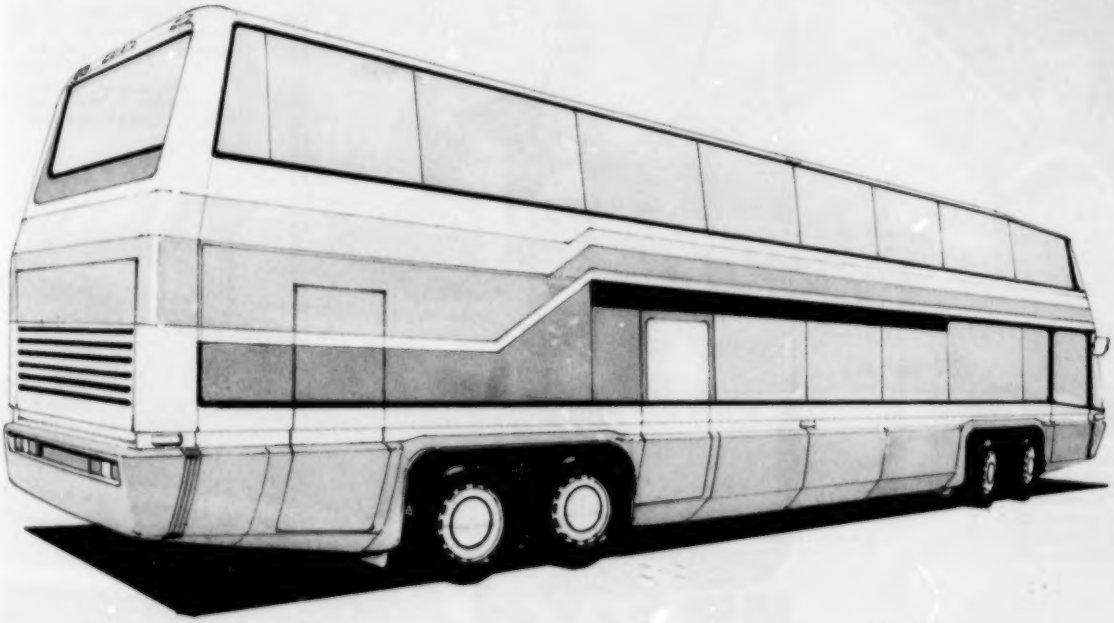
The overall requirement here is to incorporate manufacturing considerations in the original product design:

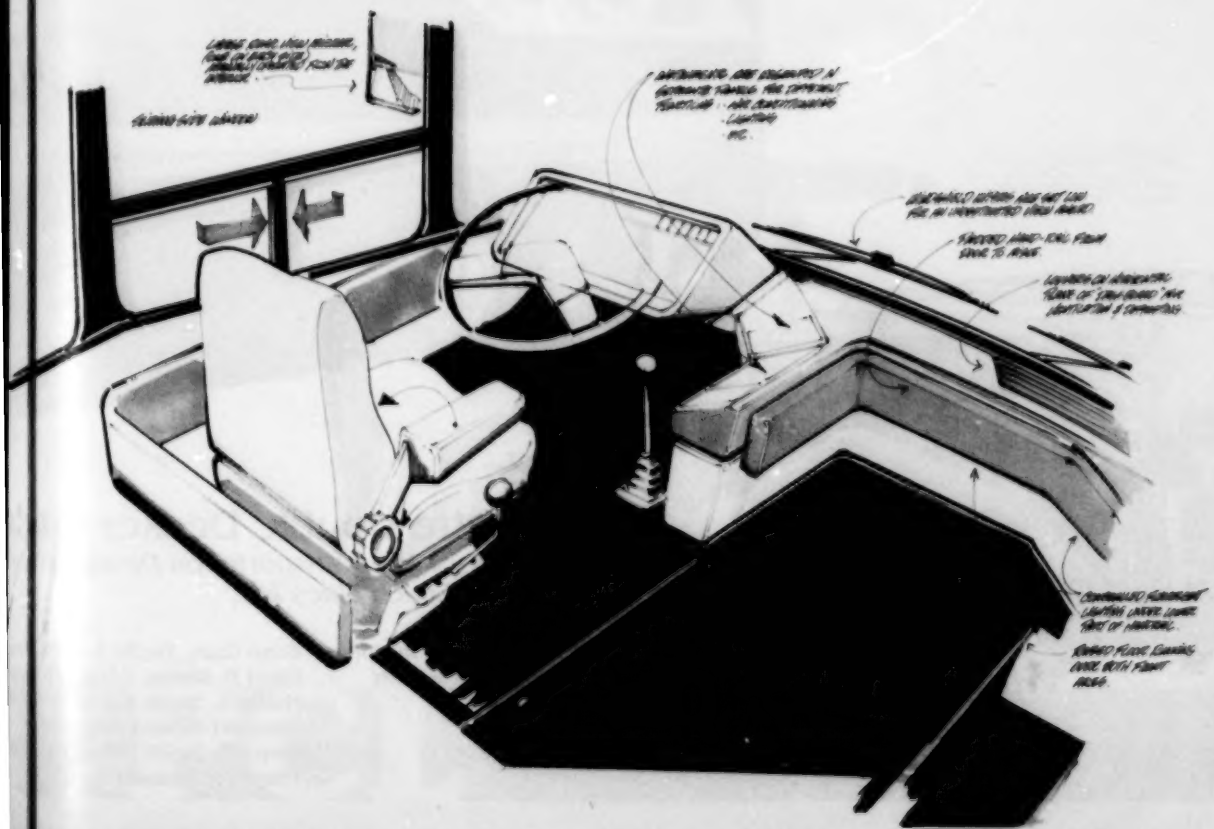
- Modularized body construction to provide a series of bus types assembled from a pool of the minimum number of fabricated parts. (The different bus types would be necessary to capture a viable segment of the North American passenger and passenger/freight market through a degree of customization: the modularity to reduce tooling and inventory costs in low volume manufacture).

- Further development of the modular approach to permit export of "kits" to foreign markets where local national content and value added requirements prevail.

The Double Decker Bus

A Transport and Industrial Opportunity for Canada





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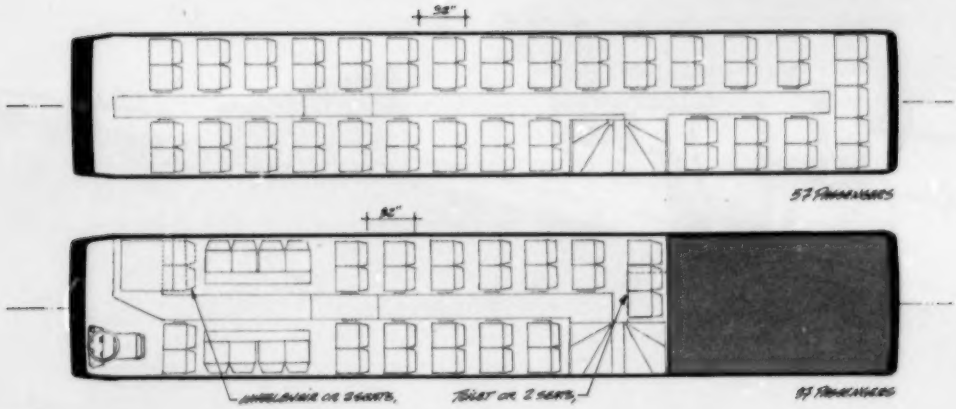

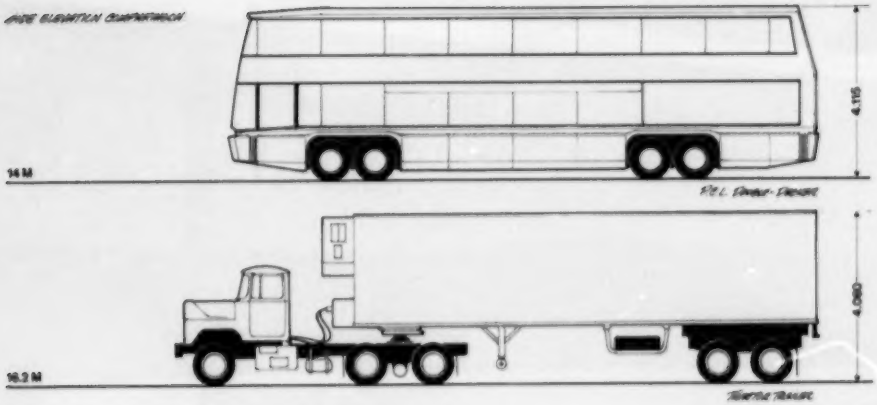

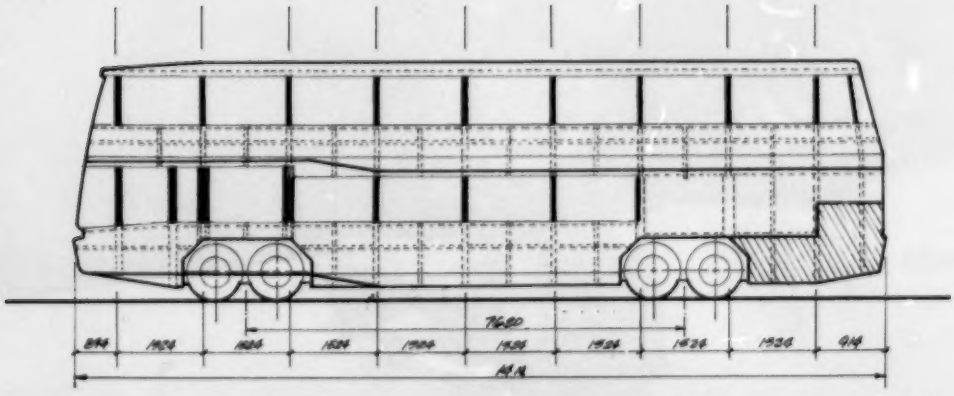

BASIC STRUCTURAL DIMENSIONS ON MODULAR FRAME PLAN

- Use of materials and construction techniques pioneered by Alcan, GSM and Associates and Bombardier Ltd. in the design and production of the handsome, cost-effective light, rapid, comfortable (LRC) train manufactured by Bombardier in Quebec and just coming into service with VIA Rail in Canada and Amtrak in the U.S.A. One key feature, made possible by the use of large aluminum extrusions (a unique capability of Alcan Ltd.) is a self-supporting, chassis-less, tubular body in which the sides act as girders receiving the floor load through the minimum number of cross members.

- Use of numerous design concepts culled particularly from aircraft designs where they are used to minimize bulk and weight and to permit speedy cleaning and replacement of the interior features.

- An engine and transmission design based initially upon the ubiquitous General Motors two-stroke diesel and Allison transmission (or near equivalents in the four-stroke diesel range) for easy maintenance by existing crews, but capable in future builds of accepting new engines operating, if necessary, on new fuels such as compressed natural gas, propane or alcohol. The design will therefore not be made obsolete by fuel or engine developments now under investigation.

4.2.2 Passenger Comfort Guidelines

The basic design (see GSM drawings) will emphasize passenger comfort and convenience aimed for the executive and business travellers who now constitute 50% of the passenger roster on many of the high capacity corridor routes in Canada and who have shown a positive response to an improved quality of service in their ridership of the Voyageur Le Grand Express (Quebec City-Montreal) and Red Arrow Service (Calgary-Edmonton). The design will overcome the deficiencies encountered in conventional intercity buses while also employing the expanded volume available in the double-decker to provide improved amenities. Particular attention is paid to:

- Ride comfort through the use of new suspension designs now underway at Hovey and Associates to provide the equivalent ride comfort to that provided in smaller vehicles by independent suspension and possibly through the use of active ride control, wherein road shocks are neutralized.

- Noise and vibration reduction through improved suspension, engine selection, engine compartment insulation and improved air conditioning.

- Seating area and arrangements in the luxury class made possible primarily by the increased volume available with two-plus-one seating accommodation with seat features found in the LRC. Spacious aisles are to be provided through use of new materials of construction which permit thinner floors. This, coupled with small wheel size, provides the maximum usable height at each level and increased headroom on both decks over that provided in conventional low-technology double-deckers.

- Specifically designed features for the handicapped will take advantage of the low floor height at the vehicle entry by providing ramps, foldable seats, wider aisles to facilitate boarding and movement of those in wheelchairs.

- Lighting and views are to be enhanced by the use of air gap double safety glass with photochromatic gray on all except the driver's windows.

- Washroom capability is available as an option, as are optional galleys and bar areas in the customized executive or tourist series.

- Improved environment through air conditioning and other features to minimize smoke and noise.

- Larger, more accessible baggage areas, including walk-in baggage areas.

4.2.3 Operational Guidelines

The design is flexible to permit expansion of the baggage area to a high volume freight operation carried at the ground level while still maintaining a section for the infirm or handicapped.

- Safety features, such as periscope surveillance of passengers on the upper deck and stairs designed to minimize accidents and provide easy access to the upper level are included.

- A particular feature of the design is the use of impact resistant, reinforced plastic side panels and a wrap-around strip to minimize vehicle damage and repairs from minor side impacts.

- The bus is designed to be serviceable by the existing complement of maintenance mechanics and with the facilities normally found in garages and terminals. The height of the bus of 4 metres may, under exceptional circumstances, require modifications in body washing facilities, or raising garage door lintels and signs, but by containing the bus to a height not greater than that of conventional tractor-trailers, the incidence of such changes should be minimal.

4.3 Tentative Costing of the Design

The costs of developing the prototype, manufacturing and unit production costs were developed by Hovey and Associates and appear encouraging. These are given in Table 4.

Engineering	Total Cost	$300,000.	
Development			
Tooling		$500,000.	
Prototype		$650,000.	
	Sub-Total	$1,450,000.	
Testing & Certification		$100,000.	
Net Development Cost		$1,550,000.	
Unit Cost:			
Material & Overhead		$232,415.	
Labour & Overhead		35,400.	
	Sub-Total	$267,815.	
G & A 18%		48,207.	
	Sub-Total	$316,021.	
Profit 10%		31,602.	
	Sub-Total	$347,624.	
Warranty 3%		10,429.	
Development amortized on 100 units		15,500.	
FOB Factory		$373,553.	(1981)
FST Extra			

Table 4 Unit and Development Cost Estimates for a Canadian Double-Deck Bus

The estimated cost of the prototype at $1,550,000 assumes it is built with competent experienced engineering management, recognizing that the production units are to be built in modest numbers in what is essentially an assembly operation. No bus company undertakes the massive engineering and tooling costs associated with large-scale automobile manufacture.

The projected unit cost at $374,000 compares favourably with those offered by Neoplan for a "medium technology" unit. The costs to upgrade the Neoplans, or any other European "medium technology" double-decker, to the required Canadian standards and environmental requirements are not known, but may substantially increase the $400,000 price currently quoted by Neoplan. A part of the cost of the prototype may be recovered by its sale, but it is assumed that the costs of the proposed development to a manufacturer would be defrayed by appropriate grants and loans, as is usual for industrial innovations of this type in Canada.

Grants for development and loans for tooling may serve to reduce the unit cost somewhat, but with an expected service life of 15+ years and the expected cost savings to be accrued through operation of the double-deckers in optimized mixed fleets, the accuracy of the cost projection is not critical to the decision to proceed with double-decker trials, or the design and testing of a prototype. The most critical items affecting costs will be the size of the manufacturing opportunity and the degree of customization required - both affect run size, labour costs and the ability to purchase components at volume rates. Market research, trials and exhibition of the prototype are required to determine the performance and costs upon which a market projection can be made and market strategies based.

5. MARKET POTENTIAL FOR A CANADIAN DOUBLE-DECK BUS

5.1 Intercity Bus Operations in Canada and the Double-Decker Opportunity

There are some 65 properties in Canada providing intercity bus services, but the potential for the double-decker and other high capacity types of bus lies with carriers among the 19 designated by Statistics Canada as Class 1 and 2 carriers listed in Table 5, each of which has annual fleet revenues in excess of $500,000. The Class 1 and 2 carriers together generated $140 million of revenues from intercity bus services in 1979 and between them returned a profit of almost $29 million although some carriers operated at a loss. Some 33 million passengers served were transported by a fleet of 1,340 intercity buses operated by these 19 companies, logging 193 million kilometres in 1979 the last year that statistics are available. The industry increased its vehicle productivity over the two years 1977 to 1979 by carrying 10% more passengers in a reduced number of buses. Climbing current costs indicate that this trend must continue. High capacity buses are one means of continuing the bus and driver productivity trend noted.

In-Province Operators

Private Ownership	Public Ownership
Eastern Canadian Greyhound (Ont.)	Ontario Northland (Ont.)
Charterways (Ont.)	Canada Coach Lines (Ont.)
SMT Eastern (N.B.)	Saskatchewan Transport Co. (Sask.)
Acadian Lines (N.B.)	Terra Transport (Nfld.)
Mackenzie Lines (N.S.)	Pacific Coach Lines (B.C.)
Metropolitan Sud (Que.)	
Metropolitan Provincial (Que.)	
Autobus Dehaies (Que.)	
Autobus Drummondville (Que.)	

Multi-Province Operators

Private Ownership	Public Ownership
Greyhound Canada (B.C., Alta., Sask., Man., Ont.)	NIL
Coachways (Alta., B.C., Yukon, N.W.T., Alaska)	
Grey Goose Lines (Man., Ont.)	
Voyageur Enterprises (Que., Ont.)	

Table 5 Intercity Bus Carriers in Canada

Analysis by Transport Canada indicates that just over 40% of intercity journeys are for business purposes and that over half the journeys are undertaken by professional or skilled personnel, indicating that an opportunity exists for premium services (such as those provided between Montreal and Quebec City and between Calgary and Edmonton). In a study of Voyageur operations (3), N.D. Lea and Associates Ltd. identified 36 Voyageur intercity routes were in service. Voyageur now reports it has 6 routes with a density sufficient to merit use of high capacity buses in services linking Quebec City, Montreal, Ottawa and Toronto. These routes account for approximately 50% of the company's revenue mileage.

The Voyageur information and the estimate of PCL's requirements are important to a market assessment. Also important are the following:

- Mixed fleets will be the most economic to operate and replacement of even a portion of existing capacity will be slow, being related to the rate of replacement (12-20 year life of a bus).

- Double-decker penetration will be limited, due to restrictions of the terminals (or added costs) attendant upon their height.

- Freight revenues approaching 30% of total revenues can be increased with a flexible double-deck passenger-freighter.

- Double-deckers will compete to some degree with articulated buses, but are preferable in intercity service (perhaps not in urban service because of their height).

- The urgency of upgrading driver productivity.

We therefore estimate that 20% of the current Canadian intercity fleet in service with the major operators (Class 1 and 2) can be replaced by double-deckers. Replacement of 20% of the 1,340 fleet gives a requirement equivalent to 270 buses of the present configuration, or 135 double-deckers. With the growth of the tourist industry and some growth of intercity passenger and freight transportation, the most plausible figure for a 10 year Canadian replacement program would lie in the range of 150-200 double-deck buses with much of the sales activity concentrated in the first five years.

5.2 The Export Opportunity

Design of the Canadian double-decker as proposed, with a height no greater than that of tractor-trailers, would remove restrictions on the market available in the U.S. and overseas. The two Canadian-based companies currently manufacturing more-or-less conventional intercity buses (Prevost of St. Claire, Que. and Motor Coach Industries (MCI) of Winnipeg, Man.) rely on export to provide the volume of production necessary to ensure economic viability: GM no longer supplies the intercity coach market. In 1978 and 1979, for example, MCI sales included sales to Saudi Arabia (197 units), Taiwan (50 units) and South Africa (12) with previous substantial export orders obtained from Australia. MCI, being owned by Greyhound, can share that company's baseline business in the U.S. with the company's own captive U.S. coach manufacturing plant, if double-deckers are accepted in the U.S.A. Greyhound U.S. would be the major account to be sought in the U.S.A. whoever the manufacturer may be.

Noting that the intercity market operates only 20% of the vehicles used within the urban and suburban market and that 400 high capacity urban (articulated) buses were ordered in 1980 in the U.S.A., and the apparent advantage in productivity of the double-decker in intercity charter and tourist service over both conventional and articulated buses, we believe that an aggressive marketing effort in the U.S.A. could provide double-decker sales in the order of 80 units per year.

Outside North America, the prospects of competing in European markets are poor, as are the prospects in the major German-dominated transport markets in South America. Looking to markets which have already accepted Canadian buses, we can see the potential for exports other than to the U.S.A. at 30-40 units per year, after market development has occurred and with active participation of the federal and provincial government agencies in promoting and financing exhibitions, trials and the export orders. This could expand when kits capable of assembly in certain of the export markets are available.

5.3 Summation of the Production Opportunity

The total potential for a production opportunity over a seven year period is as follows:

	1983	1984	1985	1986	1987	1988	1989
Canada Buses	*	-	20	40	60	50	50
U.S.A.							
Buses	-	-	-	20	35	40	40
Kits	-	*	-	5	15	30	50
Other Exports							
Buses	-	-	-	5	15	25	30
Kits	-	-	-	5	15	25	30
Total Buses	-	-	20	65	110	115	120
Total Kits	-	-	-	10	30	55	80

* Prototype delivered

Table 6 Canadian DDB Production Opportunity

A feasible sales revenue forecast for the seven year period for kits ($175,000 per set) and double-deck buses ($350,000) would be as follows:

	1983	1984	1985	1986	1987	1988	1989
Sales in millions 1981 $s							
Buses	-	-	7.0	22.75	38.5	40.25	42.0
Kits	-	-	-	17.5	5.25	9.6	14.0
Spares & service	-	-	0.4	2.05	2.25	2.55	2.8
Total	-	-	7.4	42.3	46.0	52.4	58.8
New employment in Canada	35*	45*	110	515	455	535	630

* Prototype and/start-up phase

Table 7 Canadian DDB Sales and Employment Forecasts

The employment potential in Canada generated by this level of manufacture (noting the high content of imported engines, etc. in the buses, but high value added in kits) is also estimated.

It should be noted that Pevost operates at a current level of production of about 130-150 conventional buses/year; revenues in the Prevost range could be generated by the fourth year of operations.

6. A PRODUCT DESIGN, PRODUCTION AND MARKET DEVELOPMENT STRATEGY

The opportunity at PCL, where a fleet of double-deck buses could be used in a natural deck-limited application, could be used as the starting point for a new industry in Canada and as means to assist the intercity bus operators to improve profits and service. Although there are many ways to approach this opportunity, we single out the following for consideration by all parties involved.

Step 1: Demonstration of double-deckers at PCL

Assistance be provided to PCL to acquire and demonstrate a limited number of double-deck buses on the Vancouver-Victoria and Fraser Valley runs. PCL would provide records of costs, service levels, vehicle and system performance in return for limited assistance in the purchase of two to four Neoplan Skyliners, or equivalent foreign-produced units.

Step 2: Market potential assessment

A survey be undertaken (possibly by Transport Canada) of the expanded use of double-deckers at PCL (with PCL) and other appropriate properties throughout Canada. This would include an evaluation of the total Canadian high capacity bus market and the share available to the double-decker at various cost and passenger loadings. The federal department of Industry, Trade and Commerce (or an equivalent provincial agency) should procure an export market appraisal.

Step 3: Design and costing

The appropriate government agencies to support a second phase design and cost study sufficient to provide a starting base for interested parties (potential bus manufacturers and users) to initiate their own planning.

Step 4: Initiation of entrepreneurial activity

Formation of an entrepreneurial team from industry to oversee prototype design, engineering and testing and market development. A number of companies in the West have the incentive to undertake this task, such as White Motors and Knight Manufacturing in British Columbia, although other experienced bus manufacturers, such as Prevost, may be approached. The group is expected to define the business and investment opportunity and requirements and to obtain

financial and management commitments _ including those from government.

Step 5: Prototype production and testing

Production of the first prototype bus and its testing, alongside the Neoplan units in revenue service, modification of the prototype.

Step 6: Production engineering

The production engineering required for series production of the bus (and later of kits for export) to be undertaken concurrent with testing of the prototype. A second prototype may be required. Facilities, such as the wind tunnel of the National Research Council, and computer-assisted design equipment could speed this process.

Step 7: Demonstration of prototype(s)

Presales market development can be coupled with field tests using the prototype or prototypes in service other than at PCL. Exhibitions in Canada and the U.S. would serve to build the market and order base.

Step 8: Preproduction and market development

Using PCL's requirement as the base, a run of 20-40 buses could be ordered with sufficient units placed in service by PCL to provide experience and make all corrections necessary to have smooth operations at PCL and to be able to demonstrate this level of accomplishment by the: international Transpo '86 exhibition to be held in Vancouver in 1986. This could be a key opportunity to develop the required international market.

Beyond Step 8 involvement by government could be phased out as the operation develops its markets and manufacture.

The roles involved in this series of steps to industrialization have not been assigned, but key participants appear to be at least the following:

- Pacific Coach Lines Management
- British Columbia Ministries of:
  - Municipal Affairs
  - Energy, Mines & Petroleum Resources
  - Economic Development
  - Industry and Small Business Development

- Federal government departments:
  Transport Canada
  Energy, Mines & Resources
  Industry, Trade & Commerce

- Selected industrial participants:
  Intercity bus operators
  Potential and existing vehicle manufacturers or joint venturers
  Design and engineering groups

Other strategies to develop and exploit the double-deck bus opportunity to the benefit of British Columbia and Canada can obviously be constructed but prompt and informed action is essential to capitalize upon the opportunities which have converged at this time. The short term need is for continuity in the effort to generate commercial investigation of the opportunity and to firm up the design.

7. CONCLUSIONS

"An opportunity is a course of action that is possible and obviously worth pursuing" (7).

An opportunity with considerable transport and industrial benefits has been examined in this report. These benefits can be substantial and should be supported by departments of the federal and British Columbia provincial governments. Specifically:

1. Pacific Coach Lines should be encouraged to undertake the demonstration and service evaluation of a small number of double-deck buses on its service. Financial assistance may be required, particularly to support added work involved in monitoring and checking.

2. Appropriate departments of the federal government and province of British Columbia, should undertake the funding and management of a prototype design and market analysis.

3. Initiative be taken by a provincial agency and/or the federal department of Industry, Trade & Commerce to assist in the development of a consortium or company willing to build the required engineering, manufacturing and marketing enterprise. This would be carried out by presentation of the findings from 1 and 2 and provision of financial assistance to the company or consortium, including partial financing of the first prototype and the engineering effort required for series production.

4. An industry-government task force should be promptly formed to examine the opportunity for providing a large-scale demonstration and promotion of the Canadian double-deck bus at Transpo '86. (The prototype would not be sufficient).

5. Federal and provincial funds should be allocated to selected intercity bus companies for the purchase of a number of Canadian-produced double-deck buses from the first series production upon receipt of potential feedback on the design and the market.

6. Consideration should be given to tax measures to reduce purchase costs, such as reduction or

elimination of sales taxes on domestically manufactured double-deckers.

REFERENCES

(1) Intermodal Efficiency of the Vancouver-Victoria Bus Ferry Service and a Baseline Design for a Canadian Double-Deck Bus, Hickling-Partners Inc. and Hovey & Associates (1979) Ltd.

(2) The Double-Deck Bus Demonstration Project - Executive Summary, U.S. Department of Transportation.

(3) A Feasibility Study of the Introduction of Larger Capacity Intercity Buses, N.D. Lea & Associates Ltd.

(4) The National Enery Program, 1980, Energy, Mines & Resources Canada.

(5) Project Super Bus: High-Capacity Bus Conceptual Design Study, Booz-Allen Applied Research Inc.

(6) Private Correspondance from H.C. Valentine, Science Council of Canada.

(7) Opportunities: A Handbook of Business Opportunity Search, Dr. E. de Bono.